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SEASHORE PASPALUM ECOTYPE TOLERANCE TO ROOT LIMITING SOIL STRESSES AND TRAFFIC STRESSES

1998 Research Grant: $25,000
(First Year of Support)

Dr. Robert N. Carrow
Principal Investigator

Root Limiting Soil Stresses Component

The breeding/genetics paradigm of Dr. R. R. Duncan's program for seashore paspalum (SP) (Paspalum vaginatum) is to systematically determine ecotype tolerance to important stresses. Of particular interest is genetic-based resistance to soil chemical and physical factors that limit root development/longevity. For grasses, these are: 1) high soil strength, 2) soil drought where soil drying causes death of roots that varies considerably with ecotype, 3) high soil salinity limiting root growth through physiological drought and specific ion toxicity, 4) acid soil complex which is common on kaolinitic and Fe/Al oxide soils, 5) low soil oxygen, and 6) high air and soil temperatures, especially for cool-season species.

In this project, SP ecotypes are screened for root responses to 4 of the 6 edaphic factors that limit rooting. This multiple stress approach provides important information for SP resistance to individual and multiple soil stresses and is highly effective in identifying SP ecotypes with high nutrient uptake efficiency and drought resistance via possessing a deep, extensive, viable root system. Root tolerance assessment to the major edaphic stresses has been a "missing ingredient" in almost all breeding programs targeted to improve drought resistance, water-use efficiency, or nutrient-use efficiency.

Study 1. Eighty-four seashore paspalum ecotypes and three control grasses (Common bermudagrass, Tifway, bermudagrass, and Meyer zoysiagrass) were plugged (3.5 in. dia x 3.0 in. deep) on 30 June 1998 into two adjacent sites at 4.5 feet centers. Both sites were a Cecil kaolinitic clay soil with 23% clay (A horizon) and 45% (B horizon). Site A was at pH 4.2 to create the acid soil complex stress which consists of Al/Mn toxicities and potential deficiencies of Mg, K, Ca, and P. Site B was at pH 6.5. Both sites imposed the root stresses of high soil strength in a non-cracking soil, drought stress, and high soil temperatures.

At 24 days after plugging, irrigation was stopped and all grasses experienced periods of 8, 15, and 12 days without water from 24 July to 15 September. Mowing was at 1.25 inch and fertilization was at 1.0 lb N per 1000 ft^2 as 10-10-10 on 8 July.

Multiple soil stress response was evaluated based on a Stress Index that was a combination of two factors, a) the rank of the grass according to the degree of spread over 77 days after establishment at the pH 4.2 site. Grasses that exhibited high growth under this severe stress situation should be able to grow and persist under a wide variety of irrigated/non-irrigated field conditions, and b) the ratio of growth (area covered) at pH 4.2 divided by growth at pH 6.5. This allowed identification of grasses that had the highest tolerance to the acid soil complex stress — a stress common in the Piedmont Region of the USA and very prevalent in tropical climates. Grasses with the highest ratio (1.0 = equal growth at both pH; <1.0 less growth at pH 4.2 than pH 6.5) were ranked highest. Performance of selected grasses are in Table 1.

Study 2. Nine fairway type seashore paspalums and Tifway bermudagrass were stolonized on 16 July 1998 at about a ⅓ normal rate (0.75 bu per 1000 ft^2). These will be evaluated in 1999-2000 under fairway conditions for shoot/root performance, evapotranspiration (ET) or water use, and overall drought resistance. Table 2 contains establishment data.

Other Studies

- Thirty-four (34) ecotypes will be evaluated for salinity and salinity + drought tolerances starting November 1998.
- Fifty-seven (57) seashore paspalum ecotypes plus 3 control grasses will be established in June 1999 for traffic tolerance evaluation (wear; soil compaction + wear).

Table 1. Performance of selected grasses to **multiple soil stresses** (high soil strength, drought, acid soil complex, high soil temperatures) **that limit root development**, viability, and persistence.

Grass	Stress Index Value	Stress Index Rank	Tolerance to Multiple Root-Limiting Soil Stresses[c]
HI 32 SP	15 best	1	Superior
HYB 7 SP	16	2	"
HI 34 SP	17	3	"
AP 4 SP	27	4	Very High
Com. Bermuda	29	5	"
PI 28960 SP	29	5	"
TCR 6 SP	30	6	"
96 HI 106 SP	31	7	"
Tifway bermuda	34	8	"
AP 15 SP	34	8	"
PI 509023 SP	36	9	"
Taliaferro SP	36	9	"
TCR 3 SP	37	10	"
AP 10 SP	38	11[a]	"
K 1 SP	38	11	"
K 2 SP	39	12	"
HI 101 SP	39	12	"
Fwy 1 (PI 509018-1) SP	48	20[b]	High
Adalayd SP	67	32	Moderate
Meyer zoysia	75	38	Low
Mauna Key SP	113 (worst)	54	Very Low

[a] Greens type, projected release 2000; very high salinity tolerance.
[b] Fairway type, projected release 2000; high salinity tolerance; high drought tolerance.
[c] Multiple stresses are: high soil strength; drought, acid soil complex, and high soil temperatures.

Table 2. Establishment data for nine seashore paspalums and Tifway bermudagrass in 1998. Stolonization was at 0.75 bu per 1000 ft^2 on July 16, 1998.

Grass	Plot Coverage	
	21 Aug	9 Oct
	%	
Fwy-1 SP	20.3	55.8
TCR-1 SP	9.3	33.0
TCR-6 SP	10.3	37.3
HYB 7 SP	16.8	47.5
Temple 1 SP	12.5	39.5
Taliaferro SP	6.8	22.8
AP-1 SP	6.3	18.3
Adalayd SP	8.8	36.8
Q 36313 SP	12.5	45.5
Tifway bermuda	12.0	58.5
LSD (.05)	5.9	15.4
F-test	**	**
CV (%)	35	27

**, *, † Significant difference at .01, .05, and .10, respectively.

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Objective 1

Salinity Tolerance

1. Develop and implement a salinity tolerance screening procedure that:
   - Provides salinity tolerance of SP ecotypes under well-watered and drought stress (i.e., integrates salinity and drought stresses).
   - Allows 3 salinity tolerance screening protocols to be assessed for efficiency in separating SP ecotypes and for establishing a "standard" protocol.
   - Provides detailed data on SP ecotype root tolerance data to the edaphic (soil) stresses of salinity, drought, and drought + salinity (where specific ion toxicities are accentuated).

Salt toxicity and soil drought are two of the six soil chemical and physical stresses that limit root development and viability in the field (the others are: acid soil complex; high soil strength; low soil O_2; high soil temperatures for cool-season grasses, especially). While management practices can help alleviate these root stresses, a better option is the development of ecotypes of seashore paspalum that have inherent genetic tolerance to these factors; thereby, allowing roots to develop and persist even in harsh soil conditions.

Status: This study will be initiated in late fall of 1998. A new greenhouse is being equipped with a system to allow grasses in tubes (6.4 dia. X 90 cm length) to be irrigated with six salinity levels (0, 11, 22, 33, 44, 55 dSm^{-1}, where seawater = 54 dSm^{-1}). Two sets of grass-salinity combinations will allow for salinity screening under salinity + high soil moisture and salinity + dry-down (drought) conditions. Thirty-two ecotypes will be included in this study.

Objective 2

Multiple Root Stresses

2. Determine SP ecotype tolerance to the multiple root stresses in the acid soil complex (soil strength, drought, nutrient deficiencies, element toxicities, high soil/air temperatures) that strongly influence drought resistance via drought avoidance from deep rooting.

Status. Eighty-four seashore paspalum ecotypes and three control grasses (Common and Tifway bermudagrass; Meyer zoysiagrass) were plugged (9.0 cm dia x 7.6 cm depth) into two adjacent sites, a) site 1 - severe acid soil complex conditions of pH 4.2 to induce toxicities (Al, Mn) and potential deficiencies (Mg, K, Ca) often associated with this stress complex plus additional soil stresses of high soil strength (kaolinitic clay, 25% clay), soil drought, and high soil temperatures, and b) site 2 - similar to site 1 except at pH 6.5. At 24 days after establishment on 30 June 1998, no further irrigation was applied and mowing was once every 1-2 weeks at 3.2 cm. Fertilization was at 1.0 lb N per 1000 ft^2 as 10-10-10 on 8 July 1998. Rainfall was July 24-31 (0.93 inch); August 1-14 (2.98 inch); August 15-31 (1.81 inch); September 1-15 (1.32 inch) with extended dry-downs of 8 days, 15 days, and 12 days. Each ecotype was replicated 4 times per site with 1 plug of 0.07 ft^2 initial area.

Data obtained 77 days after establishment (15 September 1998) on rate of spread are provided in Table 1. An overall "Stress Index" was developed that included two components: a) Rank A in Table 1 = the absolute growth rate in terms of spread at low pH. Grasses grown under non-irrigated high stress situations require an inherently high growth rate to achieve coverage and tolerate traffic. Thus, Rank A consisted of ranking grasses from 1 (best or highest growth rate of 6.88 ft^2) to 65 (0.18 ft^2) for a 38.2 fold difference, and b) Rank C is the ratio of spread of "low pH growth ÷ high pH growth" where a ratio of 1.00 indicates equal growth under both stress conditions. This ratio allows identification of ecotypes with superior acid soil complex tolerance since both sites had stresses of high soil strength, soil drought, and high soil temperature. But, only the low pH site had the additional stress of the acid soil complex. Grasses were ranked 1 (best) through 51. The "Stress Index" is the numerical sum of Rank A + C where the lowest sum (i.e., 15) is best. The range was 15 to 113.

Ecotypes of seashore paspalum with superior root tolerance to multiple soil stresses and selected grasses were:

Grass	Stress Index[†]	Tolerance to Multiple Root Limiting Stresses
HI 32	15 = best	Superior
HYB 7	16	
HI 34	17	
AP 4	27	Very High
C. Bermuda	29	
PI 28960	29	
TCR 6	30	
96 HI 106	31	
Tifway bermuda	34	
AP 15	34	
PI 509023	36	
Taliaferro (SP)	36	
TCR 3	37	
AP 10 (greens type)	38	

K1	38	
K2	39	
HI 101	39	
Fwy1 (PI 509018-1)	48	High
Adalayd	67	Moderate
Meyer zoysia	75	Low
Mauna Key	113 (worst)	Very Low

†A stress Index of 15 to 50 was considered as indicating high to superior multiple stress tolerance.

The SP ecotype HI 37 exhibited very limited growth at pH 6.5 but good growth at low pH. This was across replications and indicates a strong acid preference. Other grasses with reasonably high absolute growth at low soil pH and a pH ratio of >1.00 were: HI 32, PI 28920, HI 101, and TCR 3. These warrant further study as acid tolerant genotypes for extreme acid conditions such as acid sulphate soils or mine spoils.

These plots will be allowed to go into the winter and recover in the spring without any supplemental irrigation. Winter injury data will be obtained. Remaining ecotypes will be further evaluated for multiple soil stresses in the summer of 1999.

Objective 3

Multiple Soil Stresses

3. For SP ecotypes (9) with the greatest potential for release, to determine relative to Tifway bermudagrass overall drought resistance, rooting, shoot performance, and water use (ET)/soil extraction patterns under close-cut fairway conditions.

Status. Nine seashore paspalum fairway ecotypes from Dr. R. R. Duncan's breeding program were stolonized on July 16, 1998, at about ⅓ the stolon rate normally used due to limited material availability. Fertilization in pounds N per 1000 ft^2 has been 1.0 lb N on July 22 (10-10-10); 1.0 lb N on August 6 and 19 as 33-0-0, and 1.0 lb N on September 9 as 10-10-10. Mowing is as needed at 1.0 inch. Establishment data are in Table 2. This study will continue through at least 2000.

TRAFFIC STRESSES COMPONENT

Wear

4. To determine intraspecific wear resistance and recuperative potential of seashore paspalum ecotypes.

5. To define the plant characteristics that imparts resistance to the most wear tolerant ecotypes.

6. To develop a standard, efficiency and rapid screening protocol for assessing wear tolerance based on plant characteristics responsible for high wear tolerance.

Traffic (Soil Compaction + Wear)

7. To determine intraspecific traffic tolerance and recuperative potential of seashore paspalum ecotypes.

   Status: A study area has been prepared with grass establishment planned for May 1999.

Table 1. Multiple root stress tolerance of Seashore Paspalums in 1998 (T-121) (Objective 2).

Grass	I.D. No.	Low pH Ft²	Low pH Rank A	High pH Ft²	High pH Rank B	pH Ratios Low pH (Ft²) / High pH (Ft²)	Rank C	Stress Index‡ Rank A + Rank C (Low = Best)
Common Bermuda	86	6.88a†	1	12.55a†	1	.55	28	29 (5)
PI 509023	29	4.05b	2	8.65b	2	.47	34	36 (9)
Tifway Bermuda	87	2.18c	3	4.40c	3	.50	31	34 (8)
HI 34	76	1.95cd	4	2.35d	14	.83	13	17 (3)
TCR 6	7	1.70cd	5	2.83d	5	.60	25	30 (6)
96 HI 106	52	1.68cd	6	2.79d	7	.60	25	31 (7)
HYB 7	5	1.58cd	7	1.65	31	.96	9	16 (2)
HI 36	78	1.53cd	8	3.18d	4	.48	33	41 (14)
Taliaferro	30	1.40cd	9	2.40d	11	.58	27	36 (9)
HI 32	74	1.35d	10	1.23	42	1.10	5	15 (1)
AP 4	35	1.33d	11	1.84	27	.72	16	27 (4)
HI 10	65	1.28d	12	1.85	26	.69	18	30 (6)
HI 7	62	1.26d	13	2.30d	16	.55	28	41 (14)
Cloister	84	1.25d	14	2.40d	11	.52	30	44 (17)
HI 35	77	1.15d	15	2.63d	8	.44	37	52 (23)
HI 14	10	1.15d	15	2.58d	9	.45	36	51 (22)
AP 13	40	1.15d	15	2.80d	6	.41	40	55 (24)
K 2	19	1.15d	15	1.85	19	.62	24	39 (12)
HI 37	79	1.14d	16	.14	69	814.00	1	17 (3)
96 HI 102	51	1.10	17	1.69	30	.65	22	39 (12)
K 1	18	1.06	18	1.58	33	.67	20	38 (11)
Fwy 1 (PI 509018-1)	1	1.05	19	1.93	25	.54	29	48 (20)
K 8	25	1.05	19	1.59	32	.66	21	40 (13)
AP 6	37	1.04	20	2.39d	12	.44	37	57 (25)
AP 10	2	1.00	21	1.40	37	.71	17	38 (11)

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Table 1. Cont'd.

Grass	I.D. No.	Low pH Ft^2	Low pH Rank A	High pH Ft^2	High pH Rank B	pH Ratios Low pH (Ft^2) / High pH (Ft^2)	Rank C	Stress Index‡ Rank A + Rank C Low = Best
Salam (HI 25)	8	.99	22	1.69	30	.59	26	48 (20)
K 7	24	.98	23	1.80	28	.54	29	52 (23)
Q 36313	82	.98	23	1.44	36	.68	19	42 (15)
AP 15	42	.96	24	1.01	48	.95	10	34 (8)
AP 11	39	.95	25	2.38d	13	.40	41	66 (31)
HI 6	61	.94	26	1.51	35	.62	24	50 (21)
K 4	21	.94	26	1.40	37	.67	20	46 (18)
PI 28960	17	.93	27	.56	63	1.66	2	29 (5)
HI 28	69	.91	28	1.94	24	.47	34	62 (29)
Polo	85	.90	29	2.24d	17	.40	41	70 (35)
AP 1	32	.90	29	1.04	47	.87	12	41 (14)
HI 8	63	.89	30	1.24	41	.72	16	46 (18)
HI 30	72	.88	31	2.10d	19	.42	39	70 (35)
AP 5	36	.86	32	1.76	29	.49	32	64 (30)
HI 41	81	.86	32	1.93	25	.45	36	68 (33)
HI 101	55	.85	33	.81	55	1.05	6	39 (12)
Adalayd	9	.85	33	1.80	28	.47	34	67 (32)
TCR 3 (K 3 der)	13	.85	33	.75	58	1.13	4	37 (10)
K 6	23	.84	34	2.00	22	.42	39	73 (37)
K 5	22	.84	34	1.93	25	.44	37	76 (39)
HI 39	14	.83	35	.85	53	.98	8	43 (16)
K 3	20	.83	35	2.33d	15	.36	43	78 (40)
SIPV 1	47	.80	36	.85	53	.94	11	47 (19)
HI 26	68	.78	37	1.56	34	.50	31	68 (33)
HI 107	53	.78	37	1.95	23	.40	41	78 (40)

Table 1. Cont'd.

Grass	I.D. No.	Low pH Ft²	Low pH Rank A	High pH Ft²	High pH Rank B	pH Ratios Low pH (Ft²) / High pH (Ft²)	pH Ratios Rank C	**Stress Index[‡]** Rank A + Rank C
								Low = Best
TCR 4 (SIPV 1 der)	44	.76	38	.79	56	.96	9	47 (19)
HI 5	60	.72	39	1.09	45	.66	21	70 (35)
TCR 1 (MK der)	6	.70	40	2.50d	10	.28	48	88 (43)
SIPV 2-1	49	.70	40	.62	62	1.13	4	44 (17)
KC 2	56	.69	41	.96	50	.72	16	57 (25)
AP 14	3	.65	42	1.52	35	.43	38	80 (41)
Temple 1	31	.64	43	.84	54	.76	15	58 (26)
PI 509018-3	26	.64	43	1.00	49	.64	23	66 (31)
AP 9	38	.64	43	1.30	39	.49	32	75 (37)
KC 4	58	.64	43	.50	65	1.28	3	46 (18)
FSP-1	54	.63	44	.89	52	.71	17	61 (28)
HI 1	46	.63	44	2.08d	21	.30	47	91 (44)
SIPV 2	48	.61	45	.54	64	1.13	4	49 (20)
HI 13	67	.61	45	1.33	38	.46	35	80 (41)
HI 38	80	.60	46	1.85	26	.33	46	92 (45)
Temple 2	11	.59	47	.68	59	.87	12	59 (27)
TCR 2 (HI 1 der)	12	.58	48	1.18	43	.49	32	80 (41)
HI 33	75	.55	49	2.18d	18	.25	50	99 (49)
Q 36315	83	.55	49	1.30	39	.42	39	88 (43)
Utah 1	71	.55	49	1.65	31	.33	46	95 (46)
HI 2	59	.55	49	.94	51	.59	26	75 (38)
HI 12	66	.54	50	2.00	22	.27	49	99 (49)
HI 29	70	.46	51	1.33	38	.35	44	95 (46)
KC 3	57	.43	52	1.26	40	.34	45	97 (48)
Hyb 5	4	.41	53	2.00	22	.21	51	104 (52)

Table 1. Cont'd.

Grass	I.D. No.	Low pH Ft²	Low pH Rank A	High pH Ft²	High pH Rank B	pH Ratios Low pH (Ft²) / High pH (Ft²)	Rank C	Stress Index‡ Rank A + Rank C Low = Best
AP 3	34	.39	54	1.15	44	.34	45	99 (49)
HI 9	64	.38	55	.96	50	.40	41	96 (47)
AP 16	43	.36	56	1.06	43	.34	45	101 (50)
Fidalayed	50	.35	57	.44	67	.80	14	71 (36)
Meyer Zoysia	88	.34	58	.48	66	.71	17	75 (38)
AP 2	33	.31	59	.89	52	.35	44	103 (51)
PI 509020	27	.29	60	.50	65	.58	27	87 (42)
HI 31	73	.28	61	.76	57	.37	42	103 (51)
PI 509021	28	.25	62	.25	68	1.00	7	69 (34)
PI 509022	45	.24	63	.65	60	.37	42	105 (53)
Excalibre	16	.21	64	.44	67	.48	33	97 (48)
Mauna Key	15	.18	65	.64	61	.28	48	113 (54)
LSD (.05)		.82	-	1.13	-	-	-	-
F-test		**	-	**	-	-	-	-
CV (%)		62	-	47	-	-	-	-

† Top 4 statistical groups are designated by alphabetical notation of a to d.

‡ **Stress Index**: The two most important components are a) Rank A = an indicator of rapid absolute growth under low pH. This is important for rapid turf establishment and good growth under stresses, and b) Rank C = an indicator of similar growth between high and low pH. Both indicators suggest that stress tolerance is present for the multiple root stresses of acid soil complex + high soil strength + soil drought + high soil temperatures.

Table 2. Establishment data for nine seashore paspalums and Tifway bermudagrass in 1998. Stolonization was at 0.75 bu per 1000 ft^2 on July 16, 1998 (Objective 3).

Grass	Plot Coverage 21 Aug	Plot Coverage 9 Oct
	%	%
Fwy-1 SP	20.3	55.8
TCR-1 SP	9.3	33.0
TCR-6 SP	10.3	37.3
HYB 7 SP	16.8	47.5
Temple 1 SP	12.5	39.5
Taliaferro SP	6.8	22.8
AP-1 SP	6.3	18.3
Adalayd SP	8.8	36.8
Q 36313 SP	12.5	45.5
Tifway bermuda	12.0	58.5
LSD (.05)	5.9	15.4
F-test	**	**
CV (%)	35	27

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